XV. 14 CODE OF FEDERAL REGULATIONS (CFR) PART 36 APPENDIX G. TAKE-OFF NOISE REQUIREMENTS FOR PROPELLER-DRIVEN, SMALL AIRPLANE AND PROPELLER-DRIVEN, COMMUTER CATEGORY AIRPLANE CERTIFICATION TESTS ON OR AFTER DECEMBER 22, 1988

375. PART A - GENERAL

376. Section G36.1 Scope

This appendix prescribes limiting noise levels and procedures for measuring noise and adjusting these data to standard conditions, for propeller driven small airplanes and propeller-driven, commuter category airplanes specified in Secs. 36.1 and 36.501(c).

a. Explanation

Appendix G applies to the take-off noise requirements for propeller-driven small airplanes and commuter category airplanes that are tested on or after December 22, 1988, and that do not exceed 19,000 lbs. in maximum gross take-off weight. It is a self-contained document, that includes the procedures for testing, weather limitations, calculations of the reference performance, adjustments of measured noise level data to reference conditions, and noise level limits. It is organized in four sections:

- Part A – General
- Part B – Noise Measurement
- Part C – Data Correction
- Part D – Noise Limits

b. Procedures

Noise certification of small propeller-driven and commuter category airplanes in its most basic form requires a minimum of three actions, namely—

(1) Noise measurements conducted during a succession of take-off tests of the airplane within prescribed flight and noise measurement conditions. These conditions are described in paragraphs 377 to 404.

(2) Corrections and adjustments of the noise level data to account for deviations in test conditions relative to a prescribed reference condition. Corrections and adjustments are described in paragraphs 405 and 415.

(3) Demonstration, reporting, and approval that the adjusted noise levels for the airplane are within the noise limit appropriate to the airplane, which is based on the maximum certificated take-off weight of the airplane. Demonstration, reporting, and noise limits are described in paragraphs 416 to 417.

377. PART B - NOISE MEASUREMENT

378. Section G36.101 General test conditions

(a) The test area must be relatively flat terrain having no excessive sound absorption characteristics such as those caused by thick, matted, or tall grass, by shrubs, or by wooded areas. No obstructions which significantly influence the sound field from the airplane may exist within a conical space above the measurement position, the cone being defined by an axis normal to the ground and by a half-angle 75 degrees from the normal ground axis.

a. Explanation

In order to obtain consistent results, it is necessary to avoid test conditions that could affect the sound level at the measuring microphone. This regulation presents the requirements for the test site in order to uniformly measure noise levels. Uneven terrain having features such as mounds or furrows can result in reflections that could influence the measured sound levels. Vegetation can reduce the amount of sound that is reflected from the ground surface. In most cases this effect results in a reduced sound level, but under some circumstances the level may be higher. Similarly, testing over a smooth, hard surface, such as a paved area, will generally result in a higher sound level.

Obstructions in the vicinity of the microphone can also influence the measured levels. Objects such as buildings, walls, trees, vehicles, and, if close enough, test personnel, can constitute obstructions and/or cause reflections. The noise measure specified in Appendix G is based on the sound level at only one point in time, which for propeller-driven airplanes occurs when the airplane is near the overhead position. Unless the microphone is under a tree or overhang, it is unlikely that an obstruction would be between the sound source and the microphone. However, nearby objects can still affect the sound because of reflections.

b. Supplemental Information

(1) Obstructions: Obstructions within a cone centered on the microphone position, having a half-angle of 75° from the vertical at the ground surface, are not permitted.

c. Procedures

(1) Test Site Selection: When selecting the test site, it is necessary to consider topography, the condition of the ground surface, and nearby obstructions. Vegetation, such as shrubs and thick grass, in the vicinity of the microphone is not permitted. It is not permissible to place "soft" material around the microphone. In this context, soft material can include materials that do not occur naturally at the test site, such as artificial materials or soil that is prepared in such a way to make it unusually absorptive. Wet soil is not specifically addressed in the regulation, but it is likely that wet soil would result in higher noise levels and would therefore not be favorable to the applicant.

(2) Snow: Snow-covered surfaces are not addressed in the regulation; however, measured noise levels under these conditions could be lower. Conditions are considered acceptable if the snow is cleared for an area of approximately 50 feet radius around the microphone.

379. Section G36.101(b)

The tests must be carried out under the following conditions:

(1) No precipitation;
(2) Ambient air temperature between 36 and 95 degrees F (2.2 and 35 degrees C);
(3) Relative humidity between 20 percent and 95 percent, inclusively;
(4) Wind speed may not exceed 10 knots (19 km/h) and cross wind may not exceed 5 knots (9 km/h), using a 30-second average;
(5) No temperature inversion or anomalous wind condition that would significantly alter the noise level of the airplane when the nose [noise] is recorded at the required measuring point, and
(6) The meteorological measurements must be made between 4 ft. (1.2 m) and 33 ft. (10 m) above ground level. If the measurement site is within 1 n.m. of an airport meteorological station, measurements from that station may be used.

a. Explanation

This section identifies the weather conditions under which noise measurements can be made. The regulatory limitations were created to provide the greatest flexibility for applicants' noise testing with minimum effects on measured or corrected noise, to provide accurate repeatability.

b. Supplemental Information

(1) Precipitation: Fog, rain, drizzle, and snow can have a number of adverse effects. Changes in sound generation and propagation under these conditions are not well documented. Most of the equipment used for measuring noise is not intended for use during conditions of precipitation, and the effects can range from changes in microphone and windscreen sensitivity or frequency response, to arcing of condenser microphones that are not prepolarized, to possible failure of equipment because of electrical short circuits.

(2) Atmospheric Conditions: Atmospheric conditions can affect the generation and propagation of sound, for non-reference helical tip Mach numbers (see paragraph 413). Propellers generate higher noise levels at higher propeller helical tip Mach numbers. Usually the actual tip velocity is close to reference propeller tip velocity; but the speed of sound is a function of air temperature and off-reference tip Mach numbers can occur because of off-reference air temperature. The regulation requires correction for non-reference tip Mach numbers under most circumstances. However, limiting the permissible test temperature range reduces the potential magnitude of this correction. Corrections are also required to account for non-reference atmospheric absorption of sound. The magnitude of this correction is also limited by restricting the range of permissible temperature and relative humidity.

(3) Nonuniform Atmosphere: The atmosphere between the source (airplane, propeller, and exhaust) and the microphone is not uniform. There can be strong temperature gradients (positive and negative), variations in relative humidity, and variation in wind. Turbulence is also associated with strong winds, and which can cause irregular sound propagation. When there is a crosswind, it is necessary for the airplane to fly at an angle to maintain the required track over the ground. Corrections are not required to account for wind. The wind limits only provide a means of determining acceptability of the data.

(4) Weather Monitoring: Based on the above considerations, it is clearly necessary to monitor the weather conditions. Procedures used in the noise certification process for transport category airplanes and turbojet-powered airplanes call for measurement of the weather conditions between the ground and the height at which the airplane is flying (see Section A36.2.2.2 (b)). The absorption of sound in air can then be computed based on these measurements. This process requires an appreciable investment of time and resources, for propeller-driven airplanes, the magnitude of the adjustment for atmospheric absorption is less than for turbojet airplanes. An adjustment procedure based on measurements of the weather near the surface is therefore considered sufficient and more appropriate for airplanes covered by this section.

c. Procedures

(1) General Weather Measurements: The applicant is required to measure weather conditions near the surface and in the vicinity of the noise measuring station. The acceptability of noise data is contingent on the conditions being within the specified limits of Section G36.101 (b). Under the requirements of the regulations, these measurements are to be made at a height between 4 feet (1.2 meters) and 33 feet (10 meters) above ground level. This allows the use of hand-held equipment but does not preclude the use of more complex equipment of the type identified in Appendix A of Part 36 and used for turbojet-powered airplanes if the applicant chooses. The weather data may be recorded on a chart, or a Federal Aviation Administration (FAA) witnessed record of the observations may be kept.

(2) Wind: Consistent with the less complex requirements for small propeller-driven airplanes, wind conditions can be measured at the time of the airplane overflight with a relatively simple anemometer with an appropriate calibration. If the device used does not provide enough information to compute the crosswind, then the wind in any direction is limited to the crosswind limit of 5 knots. The wind limits are based on a 30-second average.

(3) Temperature and Relative Humidity Limits: Noise data are acceptable only if the air temperature is in the range from 36° to 95° Fahrenheit (F), and the relative humidity is in the range from 20 to 95 percent. Temperature and relative humidity may be measured with a psychrometer. This device measures wet and dry bulb temperatures of the air, relative humidity is then computed from these temperatures. Sufficient measurements should be made to determine all adjustments required by the regulations.

Persons responsible for performing the test should be alert to changes in the conditions. At a minimum, measurements should be made immediately before the first run in a series and immediately after the last run. This will normally result in an interval of not more than 1 hour, because the test airplane is required to refuel after 1 hour of flight time. In marginal or changing conditions, shorter intervals would be more appropriate.

(4) Use of Airport Facility: The regulations also permit the use of airport facility weather-measuring equipment. In deciding if the equipment is suitable, it is necessary to verify that the measurements are representative of the conditions near the microphone, that the equipment is providing reliable information, that the equipment has recently been calibrated, and that the equipment is FAA approved.

(5) Temperature Inversions: The effects of inversions and anomalous wind conditions are difficult to quantify. When temperature inversions are present (that is when there is one or more altitude layer in which the air temperature increases with height), flight conditions may be stable, which improves the ability of the pilot to set up a consistent, stabilized climb within the permitted operational tolerances. Also, under these conditions, it is possible to have a situation in which the surface temperature and relative humidity meet the permissible test criteria but the conditions aloft are much drier, with consequent high sound absorption characteristics and the possibility of underestimating the noise level. The noise spectrum of propeller-driven airplanes contains relatively less high- frequency noise than that of jet airplanes, so the effects may not be very significant unless there is a severe inversion.

(6) Anomalous Winds: The presence of anomalous wind conditions may be assessed by noting the airspeed variation as the airplane climbs. If the wind is uniform or changes speed or direction slowly with altitude, there is no difficulty in maintaining a constant climb speed. If there are strong variations in the wind (wind shear) or rising and descending air, there will be variations in airspeed that are not easily controllable. Variations of ±5 knots during the overflight relative to the reference velocity (Vy) are permitted by the regulation, and this criterion may be used to evaluate the presence of anomalous wind conditions.

(7) Climb Air Temperature Measurements: At the beginning of the tests and, if considered necessary, at intervals during the test, an observer on the test airplane is to monitor the air temperature during a climb. This climb may be a noise data–recording climb or may be dedicated to temperature measurement. The information must be assessed if a judgment is to be made about the acceptability of the conditions for noise measurements. The presence of anomalous wind conditions can be assessed during the data acquisition.

380. Section G36.101(c)

The flight test procedures, measuring equipment, and noise measurement procedures must be approved by the FAA.

a. Explanation

All aspects of the noise certification tests that will be used to show regulatory compliance with Part 36 are to be conducted in accordance with FAA reviewed and approved documentation. This is best accomplished by means of a detailed test plan.

b. Supplemental Information

(1) Equivalent Procedures: Equivalent procedures for determining noise levels may be proposed by the applicant. These optional procedures may be developed to supplement Part 36 procedures and evaluations. Equivalent procedures are measurement or analytical methods not identical to those specified in Part 36, but which the FAA approves equivalent results. In effect, equivalent procedures are those that are judged to provide the same certification stringency and confidence as would be obtained if the procedures were in complete compliance with Part 36.

Use of equivalent procedures may be requested by applicants for many reasons, such as to—

- Make use of previously acquired certification test data for the airplane type
- Permit more reliable demonstration of small noise level differences among derived versions of an airplane type
- Minimize the cost of demonstrating compliance with the requirements of 14 Code of Ferderal Regulations (CFR) Part 36 by keeping airplane flight time, airfield usage, and equipment and personnel costs to a minimum.

c. Procedures

(1) Test Plan: The applicant is to prepare a test plan for review and approval by the FAA. The test plan is to include descriptions of the test airplane,and the test site, details of all the equipment that will be used, flight limitations and procedures, and data adjustments. The approved test plan will control the performance of the tests and the analysis of the test results.

(2) Examples: An example of an equivalent procedure is use of flight path intercepts instead of standing start take-offs (see figure in paragraph 402). Another example of an equivalent procedure could involve the certification of a derivative model of a parent airplane for which a complete database of noise and performance measurements was obtained during the parent model's noise certification. Under these circumstances, it may be possible to show the derivative model's noise levels by doing comparison flyover tests of the derivative prototype and the parent airplanes and documenting the changes or differences between the two.

(3) FAA Approvals: No general rules can be stated for the acceptability of an equivalent procedure, and each such application is to be reviewed and approved by the FAA on its own merits. The FAA Office of Environment and Energy (AEE) has the final approval authority over all equivalent procedures. Any proposed equivalent procedures are to be documented in the test plan.

381. Section G36.101(d)

Sound pressure level data for noise evaluation purposes must be obtained with acoustical equipment that complies with section G36.103 of this appendix.

382. Section G36.103 Acoustical measurement system

The acoustical measurement system must consist of approved equipment with the following characteristics:

(a) A microphone system with frequency response compatible with measurement and analysis system accuracy as prescribed in section G36.105 of this appendix.

a. Explanation

The characteristics of the microphone system used to measure the airplane noise must be consistent with the characteristics of the noise. Different microphone designs are used for different purposes, and none provides a perfect match for all types of noise sources. Microphones with the characteristics specified in Section G36.105 are appropriate for measuring the noise of small propeller-driven airplanes.

b. Procedure

The test plan is to include a description of the proposed microphone system in a form suitable for FAA verification of compliance with the provisions of Section G36.105.

383. Section G36.103(b) & (c)

(b) Tripods or similar microphone mountings that minimize interference with the sound being measured.

(c) Recording and reproducing equipment characteristics, frequency response, and dynamic range compatible with the response and accuracy requirements of section G36.105 of this appendix.

a. Explanation

The regulations call for the microphone to be mounted in an inverted position as described in Section G36.107. All other support instrumentation and materials, including personnel, must be placed at a sufficient distance from the microphone to avoid causing contaminating effects, such as distortion of the sound field or increased background noise. Special design for the microphone mounting system is required, to avoid interference effects from the microphone holder legs and the edge effects of the plate.

Modern digital recording equipment should not have dynamic range limitation problems in recording propeller-driven small airplane noise.

b. Procedures

(1) Equipment Availability: The microphone support is to be designed to minimize reflections that could distort the sound field. An example of the microphone mounting is given in paragraph 391. Commercially available recording and reproducing equipment that meets the regulatory requirements of G36.105 is readily available.

384. Section G36.103(d)

Acoustic calibrators using sine wave or broadband noise of known sound pressure level. If broadband noise is used, the signal must be described in terms of its average and maximum root-mean-square (rms) value for non-overload signal level.

a. Explanation

Typical acoustic equipment calibrators generate either a single-frequency sound or a broadband sound. The noise measure and limits that are used to evaluate noise levels are defined in terms of the root-mean-square (rms) sound pressure level. With a broadband noise, the level of the peaks may be many times the rms value. It is therefore necessary to verify that the peaks of a broadband signal do not exceed the dynamic range of any of the system components, which could cause erroneous results.

Modern digital recording equipment should not have dynamic range limitation problems in recording propeller-driven small airplane noise.

b. Supplemental Information

(1) Field Calibrations: It is possible to calibrate measurement and recording systems in a laboratory, and in fact this is usually done. However various circumstances, such as environmental conditions, may cause minor changes in the calibrations. Unintentional damage may also occur during equipment setup and noise testing. Field calibrations are therefore required.

c. Procedure

(1) Acoustic Calibrations: An acoustic calibrator is to be used to calibrate the measurement and recording system. The root-mean-square value of the calibration signal should be reported, and, if a broadband calibrator is used, the peak level should be reported. Calibrations are to be recorded on the tape recorder

(if used) at the beginning and end of each test series and at FAA - approved intervals throughout the test when there may be any delay in the performance of the test. The system should be allowed to reach a stable operating condition in accordance with the manufacturer's recommendations prior to the initial calibration.

385. Section G36.105(a)

The noise produced by the airplane must be recorded. A magnetic tape recorder, graphic level recorder, or sound level meter is acceptable when approved by the regional certificating authority.

a. Explanation

A permanent record of each noise event is required so that the results are not solely dependent on readings taken in the field as the events occur. The means of making this permanent record are subject to approval by the FAA Local Aircraft Cetificate Office (ACO) certifying authority.

b. Supplemental Information

(1) Tape Recorders: A tape recorder preserves a complete record of the events. If there are questions about the data observed during the tests, the recorded data can be replayed, multiple times if necessary, to verify the results. A more detailed analysis of the noise signal may also be useful to the applicant for research and development purposes.

(2) Graphic Level Recorders: A graphic level recorder may provide a permanent record of the noise levels, but no replay or reproduction of the event is possible.

(3) Sound Level Meters: The record that results from the use of a sound level meter depends on the design features of the instrument. The least complex instrument uses an electromechanical needle, requiring the operator to observe the highest level reached by the needle during each event. Other, more complex instruments can be set to hold the maximum noise level reached during each event and show these levels on a digital display. Some currently available digital units are capable of storing entire time-histories of noise levels for multiple runs. These histories can be recalled to the instrument's display, transmitted to a printer, or downloaded to a computer.

c. Procedures

(1) Recommendation: The recommended procedure is to record each noise event on a tape recorder. This recorded data can be played back and analyzed as much as necessary to verify that consistent results have been obtained.

(2) Other Methods: Other methods are acceptable, provided that appropriate measures are taken to ensure the validity of the data and that the FAA approves them. Approved methods are—

(a) Obtaining a graphic level record
(b) Reading a sound level meter in the field as the event occurs and keeping a handwritten log
(c) Printing or transferring to a personal computer, the entire time - history after the test has been completed.

386. Section G36.105(b)&(c)

(b) The characteristics of the complete system must comply with the requirements in International Electrotechnical Commission (IEC) Publications No. 651, entitled "Sound Level Meters" and No. 561, entitled "Electro-acoustical Measuring Equipment for Aircraft Noise Certification" as incorporated by

reference under Sec. 36.6 of this part. Sound level meters must comply with the requirements for Type 1 sound level meters as specified in IEC Publication No. 651.

(c) The response of the complete system to a sensibly plane progressive sinusoidal wave of constant amplitude must be within the tolerance limits specified in IEC Publication No. 651, over the frequency range 45 to 11,200 Hz.

a. Explanation

There are many types of microphones and recording equipment. Not all have the high quality and characteristics necessary to ensure consistent and valid data. Specifications in the referenced documents are applicable to equipment used for sensing and recording small-airplane noise measurements.

b. Supplemental Information

At the time of preparation of this Adisory Circular (AC), International Electrotechnical Commision (IEC) 651 Publication is about to be replaced by IEC 61672, which is in draft form, and IEC 561 has been replaced by IEC 61265.

c. Procedure

(1) Approval of Equipment: FAA approval of all sensing recording and reproducing equipment is required. The equipment to be used for the noise certification tests is to be described in the test plan in sufficient detail for the FAA to determine whether it meets the required standards.

387. Section G36.105(d)

If equipment dynamic range limitations make it necessary, high frequency pre-emphasis must be added to the recording channel with the converse de-emphasis on playback. The pre-emphasis must be applied such that the instantaneous recorded sound pressure level of the noise signal between 800 and 11,200 Hz does not vary more than 20 dB between the maximum and minimum one-third octave bands.

a. Explanation

There may be circumstances in which the characteristics of the noise and the recording equipment are such that the noise signal is not adequately recorded. Electronic shaping of the noise signal may be used to correct the deficiency. This requirement applies only when the noise signal is recorded on a tape recorder.

Modern digital recording equipment should not have dynamic range limitation problems in recording propeller-driven small-airplane noise. Since the use of older analog equipment is permitted under Appendix G, the pre emphasis and de-emphasis of recorded data are still allowed.

Pre-emphasis and de-emphasis of recorded data are not allowed in International Civil Aviation Organization (ICAO) Annex 16 Chapter 10.

b. Supplemental Information

(1) Low-Frequency Noise: The noise spectra of propeller-driven airplanes consist primarily of low-frequency noise generated by the propeller. Harmonics of the propeller noise are also present and contribute to the A-weighted sound level. Most of the acoustic energy is below 1,000 (Hz), but there may be contributions from higher frequencies because of the A-weighting filter.

(2) Dynamic Range: Recording equipment, particularly the analog type, has limited dynamic range, and the airplane noise signal at higher frequencies may be below the internal noise level of the equipment. This effect can be overcome by increasing the levels in the higher frequencies before recording by pre-emphasis and then applying the opposite de-emphasis on playback. Currently available digital tape recorders have a dynamic range that greatly exceeds that of analog recorders, and pre-emphasis is not required.

(3) PreEmphasis Systems: Use of preemphasis will only be allowed if the system also employs complementary de-emphasis. Attempts to compensate for the effects of a pre-emphasis filter by applying one-third-octave de-emphasis corrections (either numerically to analyzed data or on a band-by-band basis using separate gain stages for each one-third-octave filter) will not be accepted by FAA. In addition, use of a pre-emphasis / de-emphasis system will require testing and documentation of the filters and gain stages involved to ensure that any errors are quantified and minimized and that the system performs predictably and reliably.

c. Procedure

(1) The need for preemphasis of the noise signal should be assessed, and the appropriate equipment should be included in the recording/playback system if necessary.

388. Section G36.105(e)

The output noise signal must be read through an "A" filter with dynamic characteristics designated "slow" as defined in IEC Publication No. 651. A graphic level recorder, sound level meter, or digital equivalent may be used.

a. Explanation

This section is limited to providing basic guidance on the requirements of 14 CFR Part 36 Appendix G.

b. Supplemental Information

(1) Filtered Noise Level: The noise level from each flyover test is to be measured in terms of the maximum A-weighted sound level, in decibel (dB) (A) units, using an A-weighting filter with dynamic characteristics (or meter response characteristics) designated as "slow," as defined in IEC 651, "Sound Level Meters." This A-weighting curve simulates the combined effects of hearing acuity and the human perception of loudness. In effect, the human perception of noise is very poor at low frequencies and improves as frequency increases (up to about 4,000 Hz, where it gets poorer again for even higher frequencies).

(2) Basis of Measurement: The A-weighting correction curve has been precisely defined by national and international standards (e.g., IEC 651) for the measurement of environmental noise and is a standard feature in sound level meters and other sound analysis equipment used for noise assessments. When used for this purpose, a sound level meter will provide a "thermometer-type" rating of the audible sound. This rating (or scale) is known as the A-weighted sound level and has been scientifically proven to be a good indicator of the perceived loudness of intrusive sounds. The measurement of an A-weighted sound level requires at least three separate and precise calculations, each of which must to be built into sound level meters complying with national and international standards. The sound field measured by the microphone is fluctuating sound pressure, which is converted to an equivalently fluctuating electrical signal. This signal passes through the A-weighting (frequency) filter and is subsequently time-averaged to provide a much slower fluctuating electrical signal. This time-averaged signal is converted to the decibel scale, denoted as dB, which is displayed on the meter. An A-weighted sound level is displayed in units of dB (A), where (A) means A-weighted. Each decibel scale is referenced to a pressure of 20 micropascals, equal to zero dB, which represents the threshold of human audibility of a 1,000 Hz tonal sound.

(3) Meter Response Speed: A sound level meter will (typically) have two options for time averaging - namely, "fast" and "slow" meter responses. These options govern the rate of fluctuation of the meter's needle or thermometer when the sound is rapidly varying. In effect, the fast response is extremely difficult to read on a meter when a noise is varying. The slow response is easier to read. An effective 2-second averaging time (1-second time constant) results in the slow response, which should be used in the 14 CFR Part 36 Appendix G noise tests.

(4) Maximum Sound Level: As would be expected, the measured or indicated A-weighted sound level will increase as the airplane approaches the measurement site and will decrease after the airplane passes over the site. The highest value of the A-weighted sound level that occurs during the overflight is called the maximum A-weighted sound level. This is the value that must be measured during each test.

Note carefully that this maximum value may not occur at the exact moment when the airplane is directly over the microphone. It usually occurs slightly before or after the airplane reaches the overhead position due to the directivity characteristics of propeller, engine, and exhaust noise emissions.

c. Procedure

(1) Equipment Requirements: The sound level recording equipment to be used for the tests must be described in the test plan in sufficient detail for the FAA to determine whether it meets the required standards. In using a graphic level recorder, it is important to set the writing characteristics to correspond to the slow sound level meter response, as required by the regulation.

389. Section G36.105(f)

The equipment must be acoustically calibrated using facilities for acoustic free-field calibration and if the Administrator requests analysis of the tape recording, the analysis equipment shall be electronically calibrated by a method approved by the FAA. Calibrations shall be performed, as appropriate, in accordance with paragraphs A36.3.8 and A36.3.9 of Appendix A of this part.

a. Explanation

All noise levels measured in the field or from tape-recorded data are to be determined with reference to a known source. The most reliable way to accomplish this is to calibrate equipment with a noise source of known magnitude and to compare the airplane noise signals with this known source.

b. Supplemental Information

(1) Noise Level Variability: There can be variability in the noise levels indicated by the test equipment, primarily due to environmental factors and the internal warm-up that is required by most types of equipment. Occasionally, there may be other changes due to cable problems or even equipment damage.

c. Procedure

(1) Equipment Calibration: A suitable acoustic calibrator is to be used to provide a reference sound level. This is usually accomplished by placing the calibrator on the microphone and adjusting the gain of the measuring system so that the reading corresponds to the known sound level of the calibrator. Initial final, and periodic calibrations should be used to verify that there are no major changes in sensitivity. It is important that the manufacturer’s recommended system warm-up time be observed in the field prior to equipment calibration. Calibration equipment should be identified in the test plan and is to be FAA approved.

390. Section G36.105(g)

(g) A windscreen must be employed with the microphone during all measurements of aircraft noise when the wind speed is in excess of 5 knots (9 km/hr).

a. Explanation

Under windy conditions, this turbulence causes the microphone to respond in a way that is indistinguishable from the acoustic signal. Using a suitable windscreen over the microphone can reduce the turbulence effects.

Windscreen corrections must be applied to the measured sound pressure levels if a windscreen is used during the measurements. The applicants must furnish data substantiating the correction.

The Annex 16 Chapter 10 does not accept the use of windshields for inverted microphones.

b. Supplemental Information

(1) Turbulence: Microphones are designed to respond to pressures, primarily the fluctuating pressures of acoustic signals. A fluctuating pressure can also occur as a result of turbulence from air flowing over the sensing surface of the microphone, this effect could significantly influence the measured noise level. The windscreen is to be designed to minimize interference with the acoustic signal.

c. Procedure

(1) Use of Windscreens: The use of a windscreen is mandated when the wind speed exceeds 5 knots. It is recommended that a windscreen be used at all times, not only because of the added protection it provides for the microphone, but also to enable uninterrupted measurements when the wind speed is fluctuating above and below 5 knots.

391. Section G36.107 Noise measurement

(a) The microphone must be a pressure type, 12.7 mm in diameter, with a protective grid, mounted in an inverted position such that the microphone diaphragm is 7 mm above and parallel to a white-painted metal circular plate. This white-painted metal plate shall be 40 cm in diameter and at least 2.5 mm thick. The plate shall be placed horizontally and flush with the surrounding ground surface with no cavities below the plate. The microphone must be located three-quarters of the distance from the center to the back edge of the plate along a radius normal to the line of flight of the test airplane.

a. Explanation

The Part 36 sections for large transports (Appendix C) and helicopters (Appendices H and J) require a microphone setup with the sensing element mounted 4 feet. (1.2m) above ground level. Appendix G is the only section of Part 36 that requires a microphone-mounting arrangement other than a 4 foot pole microphone. For Appendix G tests, the microphone is mounted in an inverted position so that the diaphragm is 7 millimeters (mm) above and parallel to a white-painted metal circular plate. The plate must be 40 centimeter (cm) in diameter and at least 2.5 mm thick. The plate is placed horizontally and flush with the surrounding ground surface with no cavities below the plate. The microphone is located three-quarters of the distance from the center to the edge of the plate along a radius normal to the line of flight of the test airplane. Figure 13 shows a typical inverted microphone installation.

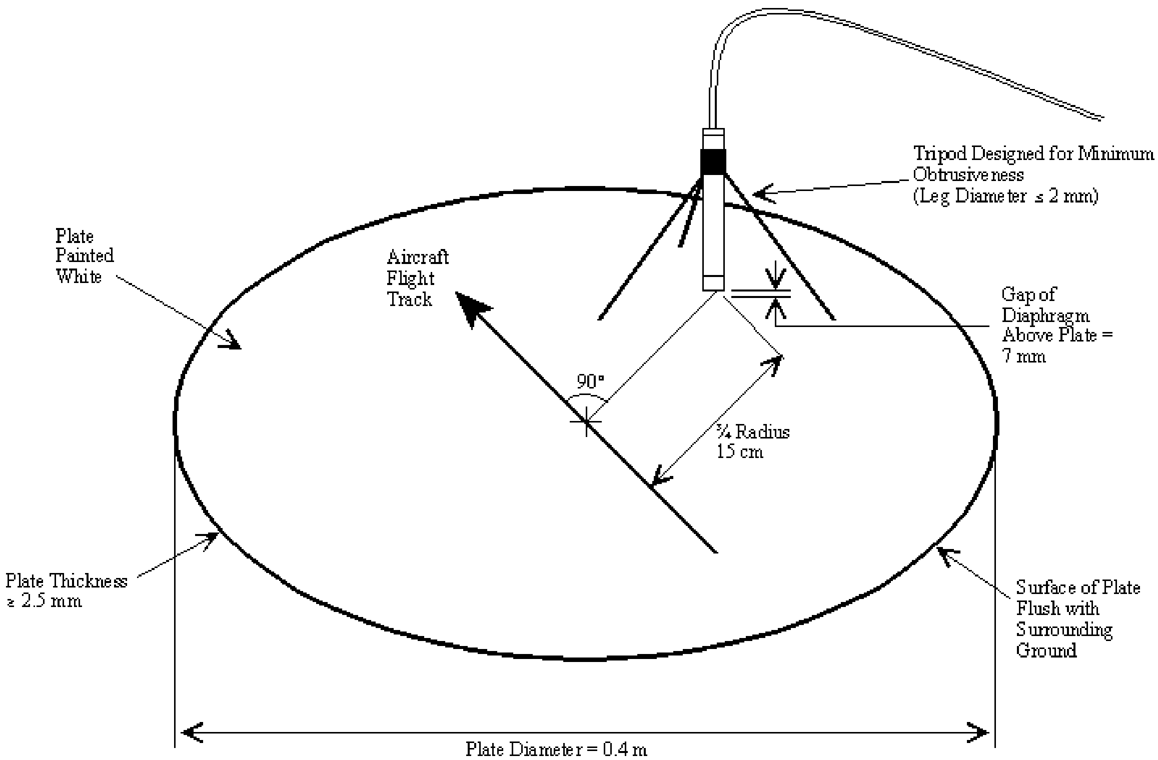

Figure 13 **Configuration for ½ in. Inverted Microphone Over Plate**

The inverted microphone setup in the above figure should be taken as an example of the design and construction of the microphone holder and the ground plate. The legs of the microphone holder must be firmly attached to the plate so that the microphone holder does not vibrate during the test. The plate must be painted white to reflect the sun's rays; such reflection will reduce the thermal effects on the microphone - sensing element. A metal spacer in the shape of a coin is a practical tool to use in setting the space between the microphone diaphragm and the ground plate. The spacer thickness should be 7 mm minus the space between the microphone protective grid and the microphone diaphragm.

Microphone sensitivity changes with frequency and the angle at which the sound reaches the microphone. To obtain consistent results, it is necessary to set up the microphone so that these changes do not influence the measured noise level.

The specified ground plane microphone configuration greatly minimizes the interference effects of reflected sound waves inherent in pole-mounted microphone installations. For a 4 foot microphone, such effects typically occur in the frequency region that is most significant for propeller-driven aircraft noise.

b. <u>Supplemental Information</u>

(1) <u>Microphone Sensitivity:</u> The specified ground plane configuration places the microphone diaphragm into an effective sound pressure field for the frequency range of interest. Microphones designed for uniform pressure response are appropriate for use in such installations.

(2) Microphone Placement: The spacing of the microphone diaphragm relative to the plate is critical, since it must be inserted completely within the effective sound pressure field, and the depth of this field varies with frequency and sensor size. For frequencies of interest, the 7 mm spacing has been determined to provide the best compromise of associated technical considerations.

(3) Alternate Configurations: The specifications for plate material, dimensions, and installation in the local ground surface represent the best practical method for obtaining an effective sound pressure field for the frequencies of interest. Experiments have been performed with many alternative configurations; however, only the specified configuration will be accepted for Appendix G noise certification purposes.

c. Procedures

(1) Plate Installation in Local Ground Surface: Care must be taken during installation to ensure that the ground surface beneath the plate is level and contains no voids or gaps. One way to achieve this is by pressing the plate into the ground surface at the desired location, applying slight pressure, then removing the plate to observe which, if any, areas under the plate are recessed. These recesses can then be filled - in with loose material, such as sand or soil, to obtain a level, uniform underlying surface. Care must also be taken to ensure that the edges of the plate are flush with the surrounding ground surface. This is especially important for plates that are thicker than the specified minimum of 2.5 mm. In some cases it may be appropriate to moisten the soil with water immediately before installation, to allow the surface to mold itself around the plate. In such cases, acoustical measurements should not be performed until the ground has dried.

(2) Design and Construction of Microphone Support: The support should be designed so that it minimizes any potential interference with sound waves from the aircraft arriving in the vicinity of the microphone. If a spider-like structure such as that in the illustration of Figure 13 is used, the number of legs should be limited to three or four. As specified, the legs must be no larger than 2 mm in diameter. Ideally the support collar should be as small as possible, and it should also implement some sort of tightening device, such as a set screw, to facilitate adjustment of the microphone diaphragm height above the plate. The support must be stable and must orient the microphone in such a way that the diaphragm is parallel to the plate.

(3) Cable Support: In some cases, it may be desirable to provide additional support to the microphone cable as it leads away from the plate. A metal rod or as similar sort of support may be used for this purpose. Any such support should be as small as possible and located as far away from the plate as is practical. The microphone cable should lead directly away from the plate without crossing above any more of the plate's surface than is necessary.

(4) Microphone Height Determination: A practical method for ensuring that the microphone diaphragm is located at the specified height above the plate is to use a temporary metal spacer. This temporary metal spacer should be constructed so that when inserted between the microphone’s protective grid and the plate’s surface, the diaphragm is located at the 7 mm height. For most microphones, the spacing between the protective grid and the diaphragm is about 1 to 1.5 mm. Once the microphone support mechanism has been secured, the spacer should be removed. The height of the spacer must account for the distance between the protective grid and the diaphragm.

(5) Windscreens: The use of windscreens is required when wind speed exceeds 5 knots. The applicant must provide data to substantiate the corrections that have to be applied to the measured sound pressure levels.

392. Section G36.107(b)

Immediately prior to and after each test, a recorded acoustic calibration of the system must be made in the field with an acoustic calibrator for the purposes of checking system sensitivity and providing an acoustic reference level for the analysis of the sound level data. If a tape recorder or graphic level recorder is used,

the frequency response of the electrical system must be determined at a level within 10 dB of the full-scale reading used during the test, utilizing pink or pseudorandom noise.

a. Explanation

Acoustic calibration is required before and after each day of testing to verify that the noise sensing, measurement, and recording equipment has maintained its quality and sensitivity.

b. Supplemental Information

(1) Component Check: The sensitivity of various components of the recording system can change during a test. These changes may result from changes in the environment (primarily temperature) or for other causes. Usually, if the equipment is turned on and allowed to stabilize before the first calibration, any changes during the test period will be small, and changes in sensitivity would be symptoms of equipment problems.

c. Procedures

(1) Calibrations: An acoustic calibrator is to be used at the start of the tests, and the reading of the system should be adjusted to the known sound level of the calibrator. The readout, indicator, or display of the system, with calibrator applied, should then be read at various intervals and at the end of the tests. Any change in sensitivity should be within manufacturer's tolerances. If a tape recorder or graphic level recorder is used, the frequency response can be evaluated by applying an appropriate input signal and determining the output. The output should be uniform as a function of frequency, within the specifications provided by the manufacturer. This procedure can be carried out in the laboratory before the start of the tests.

(2) Excessive Drift: When the measured level of the calibration at the end of the day's testing is within ±0.1 dB of the calibration value at the start of the day's testing, it can be judged that the system sensitivity did not excessively drift and that the test results are acceptable as-is. When a comparison between calibration levels measured at the start and the end of the day's testing indicates a drift in excess of ±0.1 dB, but within ±1.0 dB, a calibration drift adjustment is to be applied to all measured data as follows: Subtract the calibration signal level measured at the end of the test from the calibration signal level measured at the start of the test. Divide this difference by 2, then add the resulting calibration drift adjustment to all measured levels. If the difference in calibration levels measured at the start and the end of the day's testing exceeds ±1.0 dB, the measured data are not valid for certification use.

393. Section G36.107(c)

The ambient noise, including both acoustic background and electrical systems noise, must be recorded and determined in the test area with the system gain set at levels which will be used for aircraft noise measurements. If aircraft sound pressure levels do not exceed the background sound pressure levels by at least 10 dB (A), a takeoff measurement point nearer to the start of the takeoff roll must be used and the results must be adjusted to the reference measurement point by an approved method.

a. Explanation

Under some circumstances, the ambient noise from other sources around the test site can have an effect on the measured airplane noise levels. Alternatives should to be employed to ensure that the measured airplane noise level is at least 10 dB (A) greater than the background plus electrical system noise.

This provision was included in the regulations as a method of measuring the noise levels of aerobatic airplanes. Aerobatic airplanes, with their high climb rates, may fly high enough over the measuring location that the measured noise levels are not 10 dB (A) above the ambient noise levels. In those circumstances, the method described in this section and shown in Figure 14 may be used. For airplanes other than aerobatic airplanes, the method described in this section can only be used after AEE approval has been obtained.

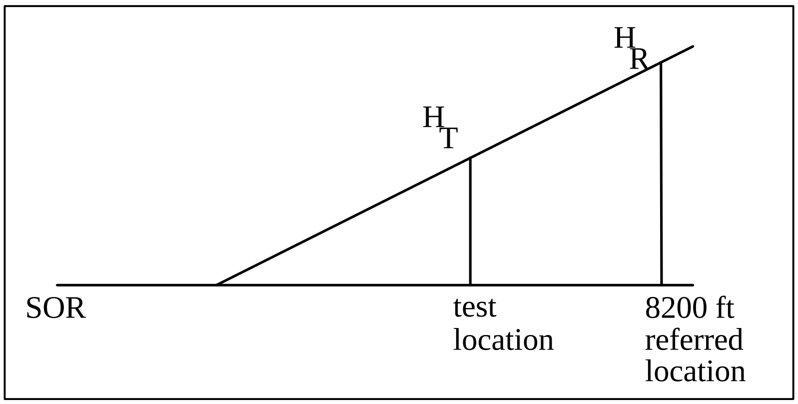

Figure 14 - Adjusted Measurement Location
(method is intended for high-performance airplanes)

Annex 16 does not have a corresponding provision, since the ICAO Annex 16 standard exempts aerobatic airplanes from noise certification.

b. Supplemental Information

(1) Background and Electrical Noise: If the equipment is properly set up, the electrical noise should be much more than 10 dB (A) below the level of the noise of the airplane. If the noise from other sources (e.g., highway, fixed power equipment) is within 10 dB (A) of the airplane noise, the applicant has two options. A quieter site can be selected (this is the best option) or the flight procedure can be changed so that the noise level of the airplane is higher. The latter case is equivalent to measuring the noise at a point closer to the start of take-off roll.

c. Procedures

(1) Increased Airplane Noise: If a site with lower noise levels cannot be used, it will be necessary to fly the airplane so that the target height over the microphone is less than it would be at the reference microphone station (8,200 feet from the start of the take-off roll) as shown in Figure 14. In this case, the airplane height at the microphone location is likely to be outside the ±20 percent tolerance specified in the regulation. Adjustment of data to reference conditions should be performed in an approved manner.

(2) Reporting Requirements: Background noise levels are to be reported to the FAA in the compliance documentation.

394. Section G36.109 Data Recording, Reporting and Approval

(a) Data representing physical measurements and adjustments to measured data must be recorded in permanent form and appended to the record, except that corrections to measurements for normal equipment response deviations need not be reported. All other adjustments must be approved. Estimates must be made of the individual errors inherent in each of the operations employed in obtaining the final data.

a. Explanation

Complete documentation of the measurement program should be provided as part of the permanent record of the noise tests. The regulation provides procedures for adjusting the measured data to reference conditions. The operational and weather data and the adjustments are to be included in the report.

b. Supplemental Information

(1) Non-reported corrections: Some corrections, such as those for frequency response of various system components, do not have to be reported if they are normal characteristics of the equipment. These corrections should be minor if the equipment meets the requirements of the regulation. Possible errors due to equipment characteristics will usually be small.

c. Procedure

(1) Data Reporting: All of the data recorded during the test program are to be reported. Any problems with the measurement system and any adjustments that were required in addition to those specified in the regulations are to be reported.

(2) Reporting Potential Errors: In most cases, potential errors due to characteristics of the measurement system should not be significant, but an assessment of these possible errors is required.

395. Section G36.109(b)

Measured and corrected sound pressure levels obtained with equipment conforming to the specifications in section G36.105 of this appendix must be reported.

a. Explanation

This section identifies the noise level reporting requirements for Appendix G noise certification testing.

b. Supplemental Information

(1) Regulatory Error: This section refers specifically to sound pressure levels. Appendix G requires measurement, adjustment, and reporting of the A-weighted sound levels, and there are no requirements for analyzing noise level data in a way that utilizes or produces sound pressure levels. The regulatory reporting requirement is interpreted as meaning A-weighted sound levels.

396. Section G36.109(c) & (d)

(c) The type of equipment used for measurement and analysis of all acoustical, airplane performance, and meteorological data must be reported.
(d) The following atmospheric data, measured immediately before, after, or during each test at the observation points prescribed in section G36.101 of this appendix must be reported:
(1) Ambient temperature and relative humidity.
(2) Maximum and average wind speeds and directions for each run.

a. Explanation

This section presents the Appendix G atmospheric reporting requirements.

b. Supplemental Information

(1) Regulatory Interpretation: The regulation identifies "each test" and "each run." For clarification, this regulation refers to each test series (test) and each test overflight (run). The (meteorological) measurements should be made at the time of each flight test, since each noise measurement will be corrected by use of the meteorological data.

(2) Wind Measurement: The requirements of Section G36.101 (b)(4) (paragraph 378, above) set the limits on testing, based on a 30-second average wind not to exceed 10 knots, with a 5 knots crosswind limitation. There are no additional limitations based on the surface wind. It is sufficient to report the 30-second average wind and crosswind that are within the regulatory limilations for each test overflight measurement.

397. Section G36.109(e)

Comments on local topography, ground cover, and events that might interfere with sound recordings must be reported.

a. Explanation

Sufficient information regarding the local topography and test site characteristics should be recorded and reported to show that the requirements of Section G36.101 (a) have been satisfied.

b. Procedures

Sufficient information should be provided to show that the requirements of Section G36.101 (a) have been met.

398. Section G36.109(f)

The aircraft position relative to the takeoff reference flight path must be determined by an approved method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation, or photographic scaling techniques.

a. Explanation

Recorded noise level data adjustments are based on the height of the airplane above the microphone station, and acceptability of each data run is based on the lateral angular offset at the microphone. An independent approved method is to be utilized to determine the airplane position relative to the approved flight track and height over the microphone.

b. Procedure

(1) Airplane Position: The height and the angular offset from the vertical at the microphone position are to be determined by an approved method, evaluated to be within the test limitations, and reported.

399. Section G36.109(g)

The following airplane information must be reported:

(1) Type, model, and serial numbers (if any) of airplanes, engines, and propellers;

(2) Any modifications or nonstandard equipment likely to affect the noise characteristics of the airplane;

(3) Maximum certificated takeoff weight;

(4) For each test flight, airspeed and ambient temperature at the flyover altitude over the measuring site determined by properly calibrated instruments;

(5) For each test flight, engine performance parameters, such as manifold pressure or power, propeller speed (rpm) and other relevant parameters. Each parameter must be determined by properly calibrated inssstruments. For instance, propeller RPM must be validated by an independent device accurate to within ±1 percent, when the airplane is equipped with a mechanical tachometer.

(6) Airspeed, position, and performance data necessary to make the corrections required in section G36.201 of this appendix must be recorded by an approved method when the airplane is directly over the measuring site.

a. Explanation

These airplane parameters must be determined and reported to determine the engine and propeller test conditions that are used for adjusting the noise level data to reference conditions.

b. Supplemental Information

(1) Required Measurements: These parameters are required in order to provide the information used in the adjustment process. Mechanical tachometers are subject to potential indicating errors as a result of the cable drive system. Separate validation of the in-flight reading is therefore required if a mechanical tachometer is used. All equipment utilized to determine the required parameters is to be calibrated, and the calibrations are to be applied before being reported to the FAA in the test report and before being used to make reference airplane corrections. The temperature at the airplane height is required for tip Mach number correction.

400. Section G36.111 Flight procedures

(a) The noise measurement point is on the extended centerline of the runway at a distance of 8200-ft (2500 m) from the start of takeoff roll. The aircraft must pass over the measurement point within ±10 degrees from the vertical and within 20% of the reference altitude. The flight test program shall be initiated at the maximum approved takeoff weight and the weight shall be adjusted back to this maximum weight after each hour of flight time. Each flight test must be conducted at the speed for the best rate of climb (Vy) ±5 knots (±9 km/hour) indicated airspeed. All test, measurement, and data correction procedures must be aooroved by the FAA.

a. Explanation

This regulation identifies the overhead flight position (height and lateral position) of the airplane during noise certification testing. The FAA-approved airplane weight and airspeed are controlled by this regulation.

b. Supplemental Information

(1) Airplane Position: The regulation requires determination of the noise level at a single location, specified relative to the start of take-off roll. Limits on the permissible deviation from the reference flight path are specified for the flight tests. These limits are based on the ability to obtain consistent, representative results, without placing excessive restrictions on the flight test. The initial take-off weight is required to be equal to the maximum approved take-off weight, and after an hour of flight time, the weight is to be increased back to this weight to account for fuel burn. This procedure ensures that the flight parameters, primarily angle of attack, do not vary significantly from the reference. The airplane position is to be FAA approved for each test overflight.

(2) Best Climb Speed: The choice of Vy for the climb speed is representative of actual airport operations. These speeds, and the resulting rate of climb, are usually available in the documentation (Pilot's Operating Handbook and/or Approved Flight Manual). The tolerance of ±5 knots from this speed allows for normal variations due to pilot technique. Variations in excess of this would be an indication of turbulence and/or anomalous winds, conditions that are unsuitable for testing.

(3) Lateral Deviation: An approved deviation of 10° from the vertical results in a reduction in measured noise level of approximately 0.1 dB, relative to the noise level for flight directly over the microphone. There are no specified corrections for this. Deviations from the reference height can occur for many reasons, including wind, airplane weight, test site elevation, and temperatures, as well as the artificial procedure used to calculate the reference height (in Section G36.111(b)). The regulation permits test heights to be within ±20 percent of the reference and requires an adjustment to account for the difference.

c. Procedures

(1) Normal Take-off: Unless an equivalent procedure is used, the airplane takes off in a normal manner and is then setup in a climb. The noise level is measured at a point 8,200 feet (2,500 m) from the start of take-off roll.

(2) Equivalent Procedure: In practice, most applicants elect to use an equivalent procedure. The normal practice for conducting noise tests is to use an intercept technique. In this technique, the airplane remains in flight and intercepts as closely as possible the reference climb path. The intercept height and location may be varied so that the correct height ±20 percent is achieved at the microphone. This procedure is acceptable because the noise level is measured only when it is at a maximum, and any maneuvering before and after that time does not affect the result, as long as the operational parameters are stabilized.

401. Section G36.111(b)

The takeoff reference flight path must be calculated for the following atmospheric conditions:
(1) Sea level atmospheric pressure of 1013.25 mb (013.25 hPa);
(2) Ambient air temperature of 59 deg. F (15 deg.C);
(3) Relative humidity of 70 percent; and
(4) Zero wind.

a. Explanation

This regulatory section identifies the reference atmospheric conditions for noise certification testing.

b. Procedures

(1) Calculation of the take-off reference flight path is a simplified representation of actual take-off and climb procedures. For the purpose of this part of the regulation, it is assumed that the atmosphere is homogeneous throughout the take-off and climb, with no change of air pressure, temperature, or relative humidity, and no wind. The selected conditions correspond to sea level and standard atmosphere, with the exception of the relative humidity. The combination of 59°F and a relative humidity of 70 percent results in low absorption of sound as it propagates the airplane to the ground, representing a worst-case scenario for the noise certification evaluation.

(2) A worked example of reference flyover height and reference conditions for source noise adjustments is provided in Appendix 5 of the Technical Manual (TM).

402. Section G36.111(c)

The takeoff reference flight path must be calculated assuming the following two segments:

a. Explanation

For analysis purposes, the flight path is separated into two segments, namely take-off roll and climb segments, as discussed in paragraphs 403 and 404, below.

The term “segment” is typically used in performance testing of airplanes and should not be confused with noise certification flight path segments. ICAO Annex 16 Chapter 10 uses the term “phases” to avoid confusion.

b. Supplemental Information

(1) Available Information: For the purpose of noise certification, the assumed take-off flight path is considerably less complex than an actual take-off, which consists of more than two segments. The assumed take-off flight paths are an artificial situation used only for noise certification purposes. Calculation of the reference flight path requires only information that is readily available to the applicant and published in the Pilot's Operating Handbook and/or Approved Flight Manual.

(2) Approval Requirements: Any information used in these data corrections or analysis calculations are to be FAA approved.

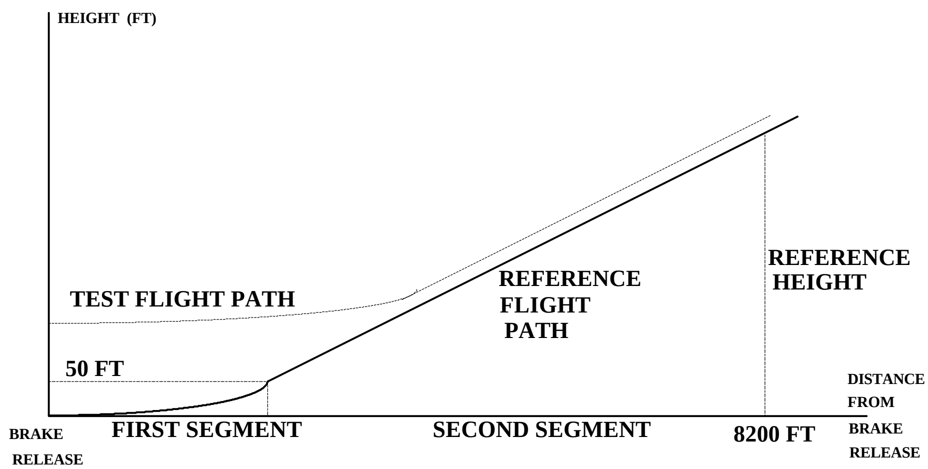

Figure 15: Typical Test and Reference Flight Paths

Figure 15, shown above, illustrates the difference between the test and the reference flight paths. Calculations may be used to determine corrections to the measured noise levels to account for the difference between the flight paths. For a sample calculation of reference and test conditions, see Appendix 5 of the Technical Manual (TM).

c. Procedure

Any information used in these calculations is to be FAA approved.

403. Section G36.111(c)(1)

First segment.

(i) Takeoff power must be used from the brake release point to the point at which the height of 50-ft (15m) above the runway is reached.

(ii) A constant takeoff configuration selected by the applicant must be maintained through this segment.
(iii) The maximum weight of the airplane at brake-release must be the maximum for which noise certification is requested.
(iv) The length of this first segment must correspond to the airworthiness-approved value for a takeoff on a level paved runway (or the corresponding value for seaplanes).

a. Explanation

The airplane weight used in the calculation is the maximum take-off weight. The first segment starts at the point of brake release and ends at the point where the airplane reaches a height of 50 feet above the runway.

b. Supplemental Information

(1) Airplane Configuration: Usually, the applicant will select a flap setting that minimizes the take-off distance to 50 feet. In some cases, there may be an advantage in selecting the position of the center of gravity to further reduce the take-off roll. There is no requirement to use the selected center of gravity position during the actual testing, nor does it become an operating limitation. The take-off configuration may be any configuration that is approved from an airworthiness point of view, and the distance required to reach a height of 50 feet is to be that listed in approved documentation.

c. Procedure

(1) Airplane Performance: The required reference airplane performance data are to be determined from approved available information (e.g., the Airplane Flight Manual).

404. Section G36.111(c)(2)

Second segment.
(i) The beginning of the second segment corresponds to the end of the first segment.
(ii) The airplane must be in the climb configuration with landing gear up, if retractable, and flap setting corresponding to normal climb position throughout this second segment.
(iii) The airplane speed must be the speed for the best rates of climb (Vy).
(iv) Maximum continuous installed power and rpm for variable pitch propeller(s) shall be used. For fixed pitch propeller(s), the maximum power and rpm that can be delivered by the engine(s) must be maintained throughout the second segment.

a. Explanation

This section presents the regulatory requirements for the climb segment, which extends from the point where the airplane reaches a height of 50 feet (end of the take-off segment) to a point over the microphone at a distance of 8,200 feet from brake release. It is assumed that this segment is at a constant climb gradient, constant configuration, and constant airspeed.

The engine power requirement for the second segment is an unharmonized item between Part 36 and Annex 16. Part 36 Appendix G allows the use of maximum continuous installed power for variable-pitch propellers during the second segment of the flight path, where as Annex 16 Chapter 10 requires maximum power if the engine is not time limited.

b. Supplemental Information

(1) Normal Take-off and Climb: In an actual take-off and climb situation, as the airplane climbs, the climb gradient, configuration, and airspeed may continuously change. In practice, the airspeed, engine power,

landing gear position, and aerodynamic configuration (flap setting) at the end of the first segment cannot instantaneously change to those used in the reference calculation of the second segment.

(2) Reference Performance: For regulatory purposes, it is assumed that the airplane configuration, airspeed, and climb gradient instantaneously change following the first segment and remain constant throughout the second segment.

(3) Airspeed: The airspeed for the best rate of climb (Vy) is typical of that used in actual airport operations and that which is determined during the airworthiness certification for the airplane.

(4) Flap Settings: The airplane must be flown in constant configuration during the second segment.

(5) Configuration: There are different requirements for fixed, and variable-pitch propellers because of the different operational characteristics. A discussion of the issues that are relevant to noise certification is provided in paragraph 339, below. In an actual take-off situation, as the airplane climbs, the climb gradient changes.

c. Procedure

(1) Applicant's Responsibility: The applicant is to determine the appropriate climb flap setting and airspeed from the airplane certification documentation (e.g., Airplane Flight Manual).

405. PART C - DATA CORRECTION

406. [RESERVED]

407. Section G36.201 Correction of Data

(a) These corrections account for the effects of:
(1) Differences in atmospheric absorption of sound between meteorological test conditions and reference conditions.
(2) Differences in the noise path length between the actual airplane flight path and the reference flight path.
(3) The change in the helical tip Mach number between test and reference conditions.
(4) The change in the engine power between test and reference conditions.

a. Explanation

Corrections are required to account for differences between the noise certification test conditions and the reference conditions.

The required corrections falls into two groups present below:

(1) Corrections to the noise levels for atmospheric absorption of sound to adjust them to acoustical reference temperature (59°F) and relative humidity (70 percent).

Corrections to the noise levels to account for differences in propeller tip helical Mach number and engine power (of the actual flights) relative to those intended under reference conditions. The term "reference conditions" is used repeatedly in 14 CFR Part 36 Appendix G and means conditions that would occur if the airplane were flown "textbook fashion" for a Vy take-off under standard atmospheric conditions (i.e., sea level, 59°F).

Most of these corrections require some calculations before the test program starts (i.e., to determine the reference conditions) and immediately after each test flight or series of test flights.

b. Supplemental Information

(1) Atmospheric Absorption: The temperature and relative humidity of the air affect the sound propagation. This correction accounts for the difference in atmospheric absorption along the sound propagation path that occurs between temperature and relative humidity under noise certification test conditions and temperature and relative humidity under reference conditions (59°F and 70 percent Relative Humidity). Refer to paragraphs 408 and 411, below, for additional atmospheric absorption correction information.

(2) Noise Path Length: As stated in paragraph 400, above, the airplane test conditions are to be at a height over the microphone within ± 20 percent of the reference height and within ± 10° of the vertical. This correction adjusts the measured noise levels for the difference in noise path length between noise test conditions and reference conditions. Refer to paragraph 411, below, for additional path length correction information.

(3) Helical Tip Mach Number: The noise generated by a propeller-driven airplane depends on the rotational speed of the tip of the propeller, more specifically the helical tip Mach number. Data corrections are based on the test condition and reference condition helical tip Mach number. Refer to paragraphs 409 and 413, below, for additional helical tip Mach number correction information.

(4) Engine Power: Corrections are required to account for non-reference engine power settings that are used during noise certification tests. The procedures for determining of the engine power to be used in the calculations depend on the design characteristics of the engine-propeller combination. In most cases, this power is not published, and does not have to be determined for airworthiness purposes. It is therefore necessary to determine the power for noise certification purposes. Refer to paragraph 414, below, for further engine power adjustment discussion.

c. Procedures

(1) Test Conditions: The noise certification test conditions of ambient temperature, relative humidity, propeller rotational speed, airplane height and engine power are to be measured or determined by an approved method during each test overflight.

(2) Reference Conditions: The certification reference conditions of propeller rotational speed, airplane height, and engine power are to be determined at reference conditions corresponding to sea level, 59°F and 70 percent relative humidity by an approved method.

408. Section G36.201(b)

Atmospheric absorption correction is required for noise data obtained when the test conditions are outside those specified in Figure G1. Noise data outside the applicable range must be corrected to 59 F and 70 percent relative humidity by a FAA approved method.

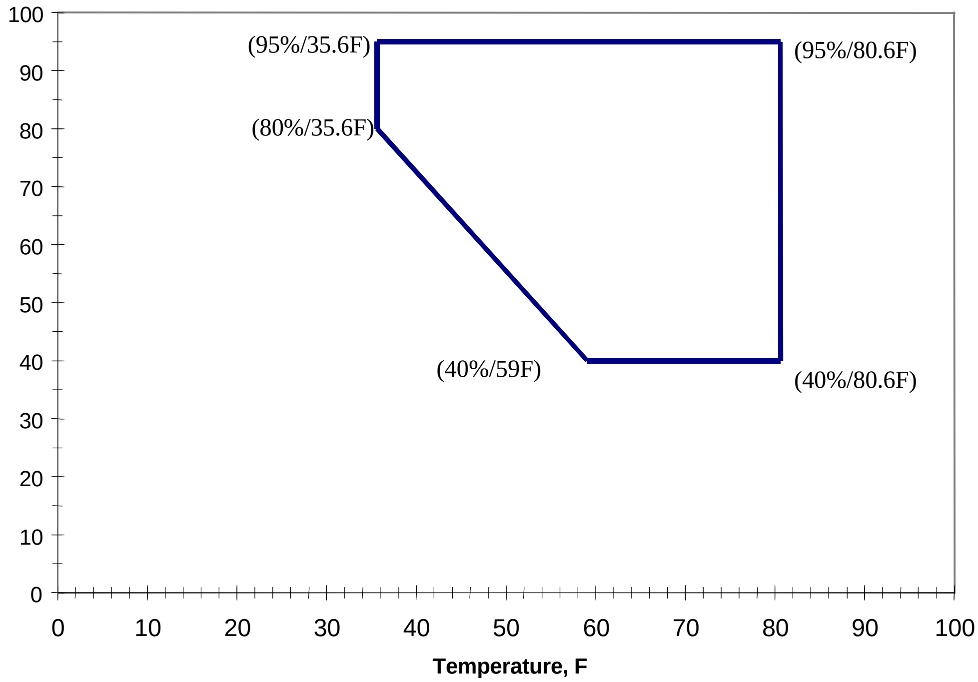

Figure 16: MEASUREMENT WINDOW FOR NO ABSORPTION CORRECTION
(Figure G1 of regulation)

a. Explanation

Corrections are required to account for the fact that the test atmospheric conditions are not the same as the reference conditions. There are two methods of making adjustments for absorption of sound in air, depending on the conditions. If the temperature and relative humidity are within the "no-correction" window shown in Figure G1 of the regulation, the adjustment is incorporated with the distance adjustment described in Section G36.201(d)(2), below. If the temperature and relative humidity are outside the specified no-correction window, then a separate adjustment is required for atmospheric absorption.

b. Supplemental Information

(1) Regulatory Inconsistencies: The information included in the regulation has an inconsistency. Figure 16 shows that the low temperature limit of the no-correction window is at 35.6°F. The low temperature limit for testing is 36°F, only 0.4° higher.

A second inconsistency was removed during harmonization. Before harmonization, (Section G36.201(b)) specified that the noise data were to be corrected to an atmospheric condition of 77°F, 25°C. Reference airplane performance is obtained for an air temperature of 59°F. This inconsistency between the acoustic and airplane performance reference conditions was corrected by adapting 59°F for both reference conditions.

409. Section G36.201(c)

Helical tip Mach number and power corrections must be made as follows:
(1) Helical tip Mach number and power corrections must be made if --

(i) The propeller is a variable pitch type; or
(ii) The propeller is a fixed pitch type and the test power is not within 5 percent of the reference power.
(2) No corrections for helical tip Mach number variation need to be made if the propeller helical tip Mach number is:
(i) At or below 0.70 and the test helical tip Mach number is within 0.014 of the reference helical tip Mach number.
(ii) Above 0.70 and at or below 0.80 and the test helical tip Mach number is within 0.007 of the reference helical tip Mach number.
(iii) Above 0.80 and the test helical tip Mach number is within 0.005 of the reference helical tip Mach number. For mechanical tachometers, if the helical tip Mach number is above 0.8 and the test helical tip Mach number is within 0.008 of the reference helical tip Mach number.

a. Explanation

For a variable-pitch propeller, adjustments are required for both helical tip Mach number and engine power. For a fixed-pitch propeller, helical tip Mach number and engine power adjustments are not required if the test power is within 5 percent of the reference.

ICAO Annex 16 Chapter 10 requires that the tip Mach number and power adjustments for both variable-pitch and fixed-pitch propellers be applied to the measured data regardless of engine power. This is an unharmonized item.

b. Supplemental Information

(1) Engine Power: Engine power depends on the atmospheric conditions, specifically, pressure altitude and air temperature. The test day conditions are likely to be different from the reference conditions, so the test engine power may not be the same as the reference engine power. Manufacturer's airworthiness approved information can be used to determine engine power for test conditions and reference conditions.

410. Section G36.201(d)

When the test conditions are outside those specified, corrections must be applied by an approved procedure or by the following simplified procedure:

a. Explanation

This adjustment is required when the ambient temperature and relative humidity combination is outside the no-correction window. It accounts for non-reference atmospheric absorption of sound when tests are conducted at conditions other than those within the allowed window.

411. Section G36.201(d)(1)

Measured sound levels must be corrected from test day meteorological conditions to reference conditions by adding an increment equal to

Delta (M) = $(H_T \alpha - 0.7 H_R)/1000$

where H_T ***is the height in feet under test conditions,*** H_R ***is the height in feet under reference conditions when the aircraft is directly over the noise measurement point and*** α ***is the rate of absorption for the test day conditions at 500 Hz as specified in SAE ARP 866A, entitled "Standard Values of Atmospheric Absorption as a function of Temperature***

and Humidity for use in Evaluating Aircraft Flyover Noise" as incorporated by reference under § 36.6.

a. Explanation

Delta (M), in decibels, is a correction for the difference in atmospheric absorption of sound between the test meteorological conditions and the acoustical reference conditions of 59°F and 70 percent Relative Humidity (RH). The applicant may use the simplified procedure provided in the regulation or may propose another procedure, which will require FAA approval.

b. Procedure

Atmospheric correction of the measured sound level data is necessary only if the meteorological conditions of temperature and relative humidity are outside specified in Figure G1 of 14 CFR Part 36, reproduced as Figure 16 in this AC.

(1) Conditions, that would be outside the measurement window include–

- Temperatures in excess of 80.6°F
- Relative humidities below 40 percent or above 95 percent
- Relative humidities between 80 percent and 95 percent for temperatures below 35.6°F
- Combinations of temperature and Relative Humidity with values below the line in Figure 16 that connects 80 percent Relative Humidity, 35.6°F and 40 percent Relative Humidity, 59°F.

In general the correction, Delta (M), is to correct for differences in sound absorption in air at different combinations of temperature and relative humidity. The correction is given by–

$$\text{Delta (M)} = (H_T\, \alpha - 0.7\, H_R)\,/1000$$

where H_T is the height (in feet) of the airplane over the noise measurement point during the actual test flight when the sound level was measured, and α is the rate of sound absorption per 1,000 feet at 500 Hz frequency, as specified in the Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 866A, entitled "Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity." The value of α at conditions of temperature and Relative Humidity can be obtained from Figure 10 of ARP 866A or from tabulations contained in Table 2 of ARP 866A, which are accurate to the first decimal place, reproduced herein as Table 4 in the AC. For test humidities other than 70 percent, ARP 866A should be used.

RATE OF ATMOSPHERIC ABSORPTION

Temp : AIR TEMPERATURE, DEGREES F
α : ATMOSPHERIC ABSORPTION COEFFICIENT, ALPHA, dB/1000 FT

500 Hz GEOMETRIC MEAN FREQUENCY
AND 70 PERCENT RELATIVE HUMIDITY

Temp	α	Temp	α	Temp	α	Temp	α	Temp	α
1	1.8	21	0.9	41	0.6	61	0.7	81	0.9
2	1.8	22	0.9	42	0.6	62	0.7	82	0.9
3	1.7	23	0.8	43	0.6	63	0.8	83	0.9
4	1.7	24	0.8	44	0.6	64	0.8	84	0.9
5	1.6	25	0.8	45	0.6	65	0.8	85	1.0
6	1.6	26	0.8	46	0.6	66	0.8	86	1.0
7	1.5	27	0.7	47	0.6	67	0.8	87	1.0
8	1.5	28	0.7	48	0.6	68	0.8	88	1.0
9	1.4	29	0.7	49	0.7	69	0.8	89	1.0
10	1.4	30	0.7	50	0.7	70	0.8	90	1.0
11	1.3	31	0.7	51	0.7	71	0.8	91	1.0
12	1.3	32	0.6	52	0.7	72	0.8	92	1.0
13	1.2	33	0.6	53	0.7	73	0.8	93	1.0
14	1.2	34	0.6	54	0.7	74	0.9	94	1.1
15	1.1	35	0.6	55	0.7	75	0.9	95	1.1
16	1.1	36	0.6	56	0.7	76	0.9	96	1.1
17	1.1	37	0.6	57	0.7	77	0.9	97	1.1
18	1.0	38	0.6	58	0.7	78	0.9	98	1.1
19	1.0	39	0.6	59	0.7	79	0.9	99	1.1
20	0.9	40	0.6	60	0.7	80	0.9	100	1.1

Table 4: Rate of Atmospheric Absorption (α) at 500 Hz Frequency

412. Section G36.201(d)(2)

Measured sound levels in decibels must be corrected for height by algebraically adding an increment equal to Delta (1). When test day conditions are within those specified in figure G1:

Delta (1) = 22 log (H_T/H_R)

where H_T is the height of the test aircraft when directly over the noise measurement point and H_R is the reference height. When test day conditions are outside those specified in figure G1:

Delta (1) = 20 log (H_T/H_R)

a. Explanation

This adjustment is based on the test height relative to the reference height. Different procedures are specified, depending on whether the test was conducted in or out of the no-correction window identified in paragraph 408, above.

b. Supplemental Information

Inverse Square Correction: The adjustment accounts for the inverse square spreading of the sound during propagation. The adjustment is based on the noise certification test height and the reference height over the microphone. Different regulatory corrections are specified, depending on whether the test was conducted in or out of the no-correction atmospheric window.

c. Procedure

(1) Determine the height, temperature, and relative humidity at the surface for each data point and compute the appropriate adjustment.

413. Section G36.201(d)(3)

Measured sound levels in decibels must be corrected for helical tip Mach number by algebraically adding an increment equal to:

Delta (2) = k log (M_R/M_T)

where M_T and M_R are the test and reference helical tip Mach numbers, respectively. The constant "k" is equal to the slope of the line obtained for measured values of the sound level in dB(A) versus helical tip Mach number. The value of k may be determined from approved data. A nominal value of k = 150 may be used when M_T is smaller than M_R. No correction may be made using the nominal value of k when M_T is larger than M_R. The reference helical tip Mach number M_R is the Mach number corresponding to the reference conditions (RPM, airspeed, and temperature) above the measurement point.

a. Explanation

This section specifies the adjustments to be made to account for non-reference propeller helical tip Mach number.

b. Supplemental Information

(1) Fixed-pitch Propeller Correction: This adjustment is not required for a fixed-pitch propeller if the engine power within 5 percent of the reference. If the test engine power is not within 5 percent the reference engine power, an approved correction is to be made.

(2) Correction Coefficient k: The format of the relationship between noise level and propeller helical tip Mach number has been developed from theoretical studies and tests. The rate at which the noise changes with Mach number is defined by the coefficient k. This has been found to vary for different installations and operating ranges.

(3) Correction Procedures: There are two alternative adjustment procedures for test Mach numbers less than reference. The regulation allows the use of an adjustment formula with k = 150 when the test helical tip Mach number (M_T) is less than the reference helical tip Mach number (M_R). When M_T is greater than M_R, k = 150 is not to be used. For most propellers, the value of k is less than 150, so this may overestimate the adjustment, resulting in a noise level greater than it would be at reference conditions. If this possible overestimation is not acceptable or desirable, approved data may be used to determine k. Possible

sources of approved data are supplementary tests in which the Mach number is varied over a sufficient range to obtain a value of k.

Section 4.1 of the ICAO Technical Manual (ref.3.j) has guidance on deriving the noise-versus-tip-Mach-number relationship.

(4) Correction Options: There are two alternatives if the test Mach number is greater than reference. One option is not to make any adjustment, thus ensuring that the noise level is not underestimated. The second option is to develop approved data, as discussed above, and use the value of k determined in this way.

(5) Correction Calculations: Calculation of the helical tip Mach number requires several steps. The propeller tip speed has two components.

- The speed at which the propeller tip is rotating (e.g., in ft/sec), denoted V_{tip}
- The forward speed of the airplane (in similar units, e.g., ft/sec), denoted V_{tas}

The respective Mach numbers for actual test and reference conditions are therefore calculated from:

$$V_{hel} = \sqrt{V_{tip}^2 + V_{tas}^2}$$

$$M_{hel} = \frac{V_{hel}}{c}$$

- The speed of sound in air at the test altitude (also similar units, e.g., ft/sec), denoted c.

where V_{hel} is the helical tip speed of the propeller and M_{hel} is the helical tip Mach number of the propeller. Calculation of V_{tip}, V_{tas} , and c for the appropriate conditions is as follows:

V_{tip} = rpm x D x π / 60, ft/sec

where rpm is that of the propeller, D is the propeller diameter in feet, and π = 3.14159

V_{cas} = airplane calibrated air speed multipied by 1 to convert from knots to ft/sec

$$V_{tas} = \frac{V_{cas}}{\sqrt{s}}$$

where $s = \frac{\Delta}{q}$

Pressure Ratio $\Delta = \left(1 - \left(6.8753E^{-6}h\right)^{5.2561}\right)$

where h is pressure altitude in feet

Temperature Ratio $q = \frac{(T(\circ F) + 459.67)}{(59 + 459.67)}$

The speed of sound c is to be calculated for the appropriate temperature conditions during the test and for the reference condition of 59°F (15°C). The value of c for reference condition calculations can be obtained from c = $\sqrt{T(^{\circ}F) + 459.67}$, ft/sec at sea level for T = 59°F - lapse rate x h (lapse rate = 0.003566°F per foot)

where h (ft) is the airplane height above mean sea level (MSL) and atmospheric conditions (temperature versus altitude) conform to a standard atmosphere.

$M_R = V_{hel}/c$ day at reference height
$M_T = V_{hel}/c$ test height

c. Procedure

(1) Applicant's Responsibility: Determine the propeller helical tip Mach number for each noise certification test overflight condition and the reference condition. When required, make the appropriate adjustment to the noise levels to account for the off-reference helical tip Mach number.

414. Section G36.201(d)(4)

Measured sound levels in decibels must be corrected for engine power by algebraically adding an increment equal to

Delta (3) = K_3 log (P_R/P_T)

where P_R and P_T are the test and reference engine powers respectively obtained from the manifold pressure/torque gauges and engine rpm. The value of K_3 shall be determined from approved data from the test airplane. In the absence of flight test data and at the discretion of the Administrator, a value of K_3 = 17 may be used.

a. Explanation

This section provides the adjustments for non-reference engine power.

In the engine power correction equation, denoted by Delta (3), P_R is the reference engine power setting at H_R (airplane over measurement point, calculated for reference flight path), and P_T is the actual test power during overflight of the microphone location. These powers are to be determined by referring to the information manual for the engine-propeller configuration and may be assessed from the engine rpm, engine manifold pressure, or other installed instrumentation appropriate to the airplane being tested, at the altitude above mean sea level.

The reference power (P_R) will be the maximum continuous installed power for a Vy (best rate of climb) take-off at sea level conditions and standard atmospheric conditions (1013.25 mb, 59°F) adjusted for reference altitude and at 70 percent Relative Humidity. This could be known from the airplane manufacturer's supplied data. If the manufacturer's data are not available, density ratio for altitude pressure and lapse rate for ambient temperature (59°F – lapse rate x H_R, lapse rate = 0.003566°F per foot) calculations can be used.

The actual test power (P_T) should be appropriate to the pressure altitude and ambient temperature of the test conditions. Typically, the field elevation plus 1,000-feet can be used to estimate the loss of engine power. Again, these data should be available in manufacturer's supplied information for the specific airplane. However, where such information is not available, a correction should be applied to the manufacturer's published engine power (normally presented for a range of engine speeds under International Standard Atmosphere (ISA) and sea level conditions) to establish the engine power level under the test conditions, as follows:

$$P_T = P_K \left[\left(\frac{T_K}{T_T} \right)^{\frac{1}{2}} \right] \left[\frac{(\sigma - 0.117)}{0.883} \right]$$, for normally aspirated engines, and

$$P_T = P_K \left[\left(\frac{T_K}{T_T} \right)^{\frac{1}{2}} \right]$$, for turbocharged engines

Where P_T and P_K are the test and known engine powers, T_K and T_T are the test and known ambient temperatures, and σ is the air density ratio.

Power correction factor K_3 can be determined by running a series of tests to obtain noise levels (dBA) versus engine power. In cases in which it is not practical to vary engine power independent of engine rpm (such as for fixed-pitch propellers) the power and helical tip Mach number can be obtained from one series of tests and applied to the data.

Section 4.1 of the ICAO Technical Manual (ref. 3.j) has guidance on deriving the noise versus tip Mach number and noise versus engine power relationships.

b. Supplemental Information

(1) Fixed-pitch Propellers: This adjustment is not required if the fixed-pitch propeller engine power for the test condition is within 5 percent of the reference engine power.

(2) Maximum Continuous Power for Airplanes with Variable-Pitch Propellers: Airplanes with variable-pitch propellers, in addition to the throttle, have a cockpit control that allows the pilot to control the propeller rotational speed (rpm). Once set, a governor maintains a constant rpm, as long as conditions are within the control range of the governor. In some instances, the engine characteristics are such that the use of take-off power is limited to a specified maximum time (e.g., 5 minutes). Maximum continuous power is less than take-off power, and reducing the engine power setting and/or the propeller rpm sets the lower power. Maximum continuous power settings that are used during the climb portion of the noise certification testing are displayed to the pilot in the form of instrument markings. These markings are in the form of green arcs for ranges where there are no time or other limitations. For piston-engine-powered airplanes, the limiting rpm is usually stated in terms of engine rpm, so with geared propellers the propeller rpm can be determined directly from the gear ratio. The engine power setting parameter, controlled by the throttle, may be the manifold pressure, that is the absolute pressure in the manifold that supplies air to the cylinders. For turboprop installations, there is usually a direct control for the propeller rpm, although it may have only two speeds and may not be infinitely variable. The power setting parameter may be in several different forms, such as propeller (or other) shaft torque, or the temperature of the burned air-fuel mixture at the turbine inlet (TIT).

(3) Maximum Continuous Power for Airplanes with Fixed-Pitch Propellers: Many small airplanes are designed to use a fixed-pitch propeller. With these airplanes, the pilot has only a throttle control with no separate control of propeller pitch. The rpm is dependent on the flight regime and throttle setting. At maximum throttle, as used for take-off and climb conditions, the rpm is appreciably less than maximum, and the engine does not develop its rated power. There is a small increase in rpm as the airplane accelerates on the runway to in-flight airspeed, but the rpm is still appreciably below the maximum. Maximum engine rpm cannot be achieved until the airplane is in the cruise phase of flight. The engine power that is achieved during the climb portion of the flight is to be considered the reference power for noise certification purposes and may be dependent on the airport altitude (ambient pressure), temperature, and relative humidity. The airplane manufacturer's data can provide reference power information.

(4) Determination of Power for Piston Engines: Engine manufacturers provide charts that can be used to determine the power developed by the engine under various operating conditions. The variables that control engine power are rpm, manifold pressure, density altitude, and ambient air temperature. These charts usually apply to a test-bench situation, with no power losses due to power extraction (alternators, pumps, etc.) and with an air intake and exhaust system designed for test-bench use. In practice, using the un-installed power for both test and reference conditions will provide satisfactory results, when FAA approved.

c. Procedure

(1) Engine Power Adjustment: Determine the engine powers for each test overflight condition and use an approved procedure to adjust the measured noise levels to reference conditions.

415. Section G36.203 Validity of Results

(a) The measuring point must be overflown at least six times. The test results must produce an average noise level (Lamax) value within a 90 percent confidence limit. The average noise level is the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point.

(b) The samples must be large enough to establish statistically a 90 percent confidence limit not exceeding ±1.5 dB (A). No test results may be omitted from the averaging process unless the omission is approved by the FAA.

a. Explanation

At least six test data points are required to satisfy this regulatory section. The certification noise level is then determined from the arithmetic average of these tests noise levels. All valid data points are to be included in the average. A statistical test is applied to ensure that the average has been adequately determined. The 90 percent confidence limit, computed using established statistical methods, may not exceed ± 1.5 dB (A).

b. Supplemental Information

(1) Valid Data: Test points may not be excluded without the approval of the FAA. Exclusions will not be approved unless there is a valid technical reason. Arbitrary exclusion of a test point on the basis of its measured level is not permitted.

(2) Confidence Limit Exceedance: If the 90 percent confidence limit does not satisfy the ± 1.5 dB (A) requirement, the only recourse is to obtain additional test data and increase the number of events until the confidence limit is reduced to ± 1.5 dB (A). The variability of data obtained under controlled conditions should be substantially less than ± 1.5 dB. If the 90 percent confidence interval is near or above the permitted limit, the approved test procedures and/or correction procedures should be carefully reviewed.

c. Procedures

(1) Average Noise Level Calculations: Calculation of the average noise is accomplished by summing the adjusted noise levels of the data points and dividing by the number of values in the sample. This can be written as:

$$\left(LA_{\max}\right)_{avg} = \frac{1}{N}\sum_{i=1}^{n} LA_{\max(i)} = \frac{1}{N}\left[LA_{\max(1)} + LA_{\max(2)} \ldots LA_{\max(n)}\right]$$

where $LA_{max(i)}$ is the corrected noise level of the i^{th} , test flight and N is the total number of test results in the calculation of the average. When the condition of 90 percent confidence limits to be within 1.5 dB (A) is met by data from six or more test flights, then the average corrected noise level $(LA_{max})_{avg}$ resulting from the validated data can be used to determine conformity with the Appendix G Noise Levels, as described in Section G36.301.

(2) Confidence Level Calculations: Other statistical terms are used to quantify the ***scatter*** of the values around the average value and the ***range*** (above and below the average value) that a test result should fall within, with a stated confidence. These terms are known respectively as:

(1) The standard deviation of the results
(2) The confidence limits (in our case, ±1.5 dB (A)) that are a range above and below the average value for a stated confidence (in our case, 90 percent probability).

The requirement on the confidence limits (of the corrected noise level data) is based on a statistical test involving the number of test results (N) and the standard deviation(s) of the test noise levels.

$$s = \sqrt{\frac{1}{(\mathrm{N}-1)}\sum_{i=1}^{\mathrm{N}}\left(LA_{\max} - (LA_{\max})_{avg}\right)^2}$$

$$= \sqrt{\frac{1}{(\mathrm{N}-1)}\sum_{i=1}^{\mathrm{N}}\left(x_i - \bar{x}\right)^2}$$

where

$X_i = LA_{\max(i)} =$ the corrected noise level, in dBA of the i^{th} valid test flight

$\bar{x} = (LA_{\max})_{avg} =$ the average of the corrected noise levels, as described earlier in this section. After calculating the standard deviation(s), the 90 percent confidence interval can be calculated using the equation:

CI (confidence interval) $= \pm t\,\frac{S}{\sqrt{\mathrm{N}}}$

where t = Student's *t* distribution for 90 percent confidence interval and V degrees of freedom (from Table 5)

N = number of data points
V = degrees of freedom = N - 1

Degree of Freedom (V)	Student's *t* Distribution for 90 percent Confidence Interval
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
12	1.782
14	1.761
16	1.746
18	1.734
20	1.725
24	1.711
30	1.697
60	1.671
∞	1.645

Table 5

416. PART D - NOISE LIMITS

417. Section G36.301 Aircraft Noise Limits

(a) ***Compliance with this section must be shown with noise data measured and corrected as prescribed in Parts B and C of this appendix.***

(b) ***The noise level must not exceed 76 dB (A) up to and including aircraft weights of 1,320 pounds (600 kg). For aircraft weights greater than 1,320 pounds, the limit increases from that point with the logarithm of airplane weight at the rate of 9.83 dB (A) per doubling of weight, until the limit of 88 dB (A) is reached, after which the limit is constant up to and including 19,000 pounds (8,618 kg). Figure G2 shows noise level limits vs. airplane weight.***

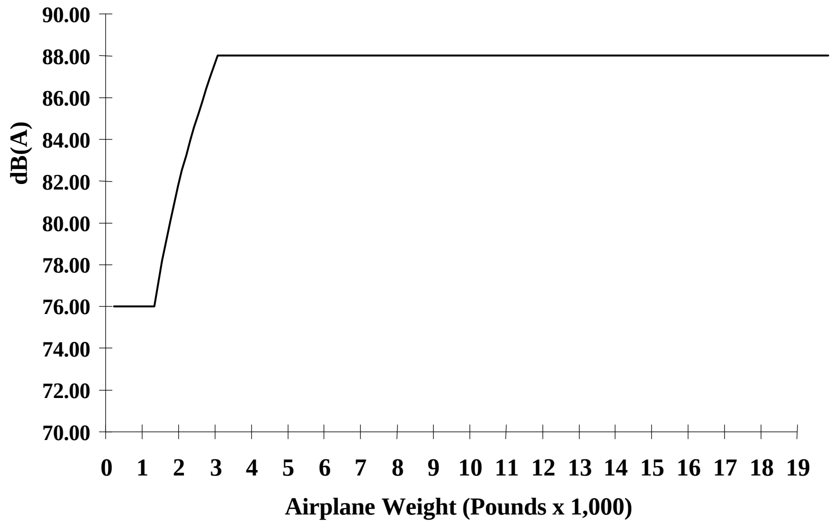

Figure 17 - Noise Level vs. Airplane Weight (Figure G2 of part 36, Appendix G)

a. Explanation

The noise level limit varies depending on the maximum certificated take-off gross weight according to the specified formula, as depicted in Figure 17.

b. Supplemental Information

(1) Noise Level Limits: The form of the weight/limit relationship is log between airplane weights of 1,320 pounds and 3,086 pounds. This format differs from that used to determine the noise level limits for other aircraft under 14 CFR Part 36.

W = Maximum takeoff weight in pounds

	0	1320	3086	19000
Noise level in dB (A)	76	32.67 log W – 26.0	88	

c. Procedure

(1) Limit Comparison: The noise level limit is computed based on the maximum take-off gross weight and compared with the average measured (and corrected) noise level in terms of dB (A).

418. –429. [RESERVED]